7.0 HABITAT INFORMATION FOR GOA AND BSAI FORAGE FISH

7.1 Amendment 36/39 Background

Amendment 36 to the BSAI groundfish FMP and Amendment 39 to the GOA groundfish FMP defines a forage fish species category in both FMPs and implement associated management measures. The intended effect of this action is to prevent the development of a commercial directed fishery for forage fish, which are a critical food source for many marine mammal, seabird and fish species. Forage fish are abundant fishes that are preyed upon by marine mammals, seabirds and commercially important groundfish species. Prior to regulations implemented under these amendments, the FMP structure potentially could have allowed unrestricted commercial harvest to occur on forage fish species because these species were grouped into the "other species" and non-allocated categories of the FMPs.

Because amendments 36/39 established forage fish as a separate category in the groundfish FMPs, EFH must be defined for these species. The forage fish species category includes all species of the following families:

Osmeridae (eulachon, capelin and other smelts),
Myctophidae (lanternfishes),
Bathylagidae (deep-sea smelts),
Ammodytidae (Pacific sand lance),
Trichodontidae (Pacific sand fish),
Pholidae (gunnels),
Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs and shannys),
Gonostomatidae (bristlemouths, lightfishes, and anglemouths),and
the Order Euphausiacea (krill).

7.2 Biological Information on Forage Fish

Because information on forage fish was not included in the Preliminary Essential Fish Habitat Assessment Reports, we have included all available information here that was used by NMFS for their EFH recommendations.

Forage fish species are abundant fishes that are preyed upon by marine mammals, seabirds and other commercially important groundfish species. Forage fish perform a critical role in the complex ecosystem functions of the Bering Sea and Aleutian Islands management area and the Gulf of Alaska by providing the transfer of energy from the primary or secondary producers to higher trophic levels. This analysis has grouped the following forage fish species into the new category: Osmeridae (which includes capelin and eulachon), Myctophidae, Bathylagidae, Ammodytidae, Trichodontidae, Pholidae, Stichaeidae, Gonostomatidae, and the Order Euphausiacea.

7.2.1 Abundance, Distribution, and Food Habits

Forage fishes as a group occupy a nodal or central position in the North Pacific food web, being consumed by a wide variety of fish, marine mammals and seabirds.

Many species undergo large, seemingly unexplainable fluctuations in abundance. Most of these are R-selected species (e.g. pollock, herring, Atka mackerel, capelin, sand lance), which generally have higher reproductive rates, are shorter-lived, attain sexual maturity at younger ages, and have faster individual growth rates than K-selected species (e.g., rockfish, many flatfish). Predators which utilize r-selected fish species as prey (marine mammals, birds and other fish) have evolved in an ecosystem in which

fluctuations and changes in relative abundances of these species have occurred. Consequently, most of them, to some degree, are generalists who are not dependent on the availability of a single species to sustain them, but on a suite of species any one (or more) of which is likely to be abundant each year.

There is some evidence, mostly anecdotal, that osmerid abundances, particularly capelin and eulachon, have declined significantly since the mid 1970s. Evidence for this comes from marine mammal food habits data from the Gulf of Alaska (Calkins and Goodwin 1988), as well as from data collected in biological surveys of the Gulf of Alaska (not designed to sample capelin; Anderson et al. in press) and commercial fisheries bycatch from the eastern Bering Sea (Fritz et al. 1993). It is not known, however, whether smelt abundances have declined or whether their populations have redistributed vertically, due presumably to warming surface waters in the region beginning in the late 1970s. This conclusion could also be drawn from the data presented by Yang (1993), who documented considerable consumption of capelin by arrowtooth flounder, a demersal lower-water column feeder, in the Gulf of Alaska.

Smelts (Capelin, Rainbow Smelt and Eulachon). Smelts (family Osmeridae) are slender schooling fishes that can be either marine (such as capelin) or anadromous (rainbow smelt and eulachon). Figure 8.1 shows a generalized distribution of these three smelt species in the southeastern Bering Sea based on data collected by NMFS summer groundfish trawl surveys and by fisheries observers.

Capelin are distributed along the entire coastline of Alaska and south along British Columbia to the Strait of Juan de Fuca. In the North Pacific, capelin can grow to a maximum of 25 cm at age 4. Most capelin spawn at age 2-3, when they are only 11-17 cm (Pahlke 1985). Spawning occurs in spring in intertidal zones of coarse sand and fine gravel--especially in Norton Sound, northern Bristol Bay and Kodiak. Very few capelin survive spawning. The age of maturity of capelin in the Barents Sea has been shown to be a function of growth rate, with fast-growing cohorts reaching maturity at an earlier age than slow-growing cohorts. Thus, it is possible to have slow and fast-growing cohorts mature in the same year, resulting in large spawning biomasses one year preceded and potentially followed by small spawning biomasses.

In the Bering Sea adult capelin are only found near-shore during the months surrounding the spawning run. During other times of the year, capelin are found far offshore in the vicinity of the Pribilof Islands and the continental shelf break. The seasonal migration may be associated with the advancing and retreating polar ice front, as it is in the Barents Sea. In the eastern Bering Sea, winter ice completely withdraws during the summer months. If migration follows the ice edge, the bulk of the capelin biomass in the Bering Sea could be located in the northern Bering Sea, beyond the area worked by the groundfish fisheries and surveys. Very few capelin are found in surveys, yet they are a major component of the diets of marine mammals feeding along the winter ice edge (Wespestad 1987), and of marine birds, especially in the spring. In the Gulf of Alaska, which remains ice free year round, capelin overwinter in the bays of Kodiak Island and in Kachemak Bay.

Rainbow smelt ascend rivers to spawn in spring shortly after the breakup of the ice. After spawning, they return to the sea to feed. Surveys have found concentrations of rainbow smelt off Kuskokwim Bay, Togiak Bay and off Port Heiden, but they also probably occur in many nearshore areas near river mouths. Rainbow smelt mature at ages 2-3 (19-23 cm), but can live to be as old as 9 years and as large as 30 cm. Little is known about trends in abundance of this species.

Eulachon also spawn in spring in rivers of the Alaska Peninsula, and possibly other rivers draining into the southeastern Bering Sea. Eulachon live to age 5 (and grow to 25 cm), but most die following first spawning at age 3. Eulachon are consistently found by groundfish fisheries and surveys between Unimak Island and the Pribilof Islands in the Bering Sea, and in Shelikof Strait in the Gulf of Alaska (Figure 8.1).

Evidence from fishery observer and survey data suggests that eulachon abundances declined in the 1980s (Fritz et al. 1993). These data should be interpreted with caution since surveys were not designed to sample small pelagic fishes such as eulachon, and fishery data was collected primarily for total catch estimation of target groundfish. Causes of the decline, if real, are unknown, but may be related to variability in year-class strength as noted for capelin.

Pacific Sand Lance (Ammodytidae). Pacific sand lance are usually found on the bottom, at depths between 0-100 m except when feeding (pelagically) on crustaceans and zooplankton. Spawning is believed to occur in winter. Sand lance mature at ages 2-3 years and lengths of 10-15 cm. Little is known of their distribution and abundance; they are rarely caught by trawls. In the Bering Sea, sand lance are common prey of salmon, northern fur seals and many species of marine birds. Thus, they may be abundant in Bristol Bay, along the Aleutian Islands and Alaska Peninsula. In the Gulf of Alaska, sand lance are prey of harbor seals, northern fur seals and marine birds, especially in the Kodiak area and along the southern Alaska Peninsula. Given the sand lance's short life span and the large number of species which prey on it, mortality, fecundity and growth rates of Pacific sand lance are probably high.

Myctophidae and Bathylagidae. Myctophids (lanternfishes) and bathylagids (deep-sea smelts) are distributed pelagically in the deep sea throughout the world's ocean. Most species in both families occur at depth during the day and migrate to near the surface to feed (and be fed upon) at night. A common myctophid in the Bering Sea and Gulf of Alaska is the northern lampfish (*Stenobrachius leucopsarus*), which has a maximum length of approximately 13 cm. Bathylagids of the north Pacific include *Bathylagus* spp. (blacksmelts) and *Leuroglossus stilbius schmidti* (northern smoothtongue), each of which have maximum lengths of between 12-25 cm. Myctophids and bathylagids are important forage fishes for marine birds and marine mammals. Since they are rarely caught in survey or fishery trawls, nothing is known of recent trends in their abundance.

Pacific sandfish (Trichodontidae). The Pacific sandfish (*Trichodon trichodon*) lives in shallow inshore waters to about 50 m depth and grows to a maximum length of 30 cm. Nothing is known of trends in their abundance. They are feed upon by salmon and other fish, as well as pinnipeds.

Euphausiids. Along with many copepod species, the euphausiids form a critical zooplanktonic link between the primary producers (phytoplankton) and all upper pelagic trophic levels. These crustaceans, also known as krill, occur in large swarms in both neritic and oceanic waters. Members of at least 11 genera of euphausiids are known from the North Pacific, the most important (in terms of numbers of species) being *Thysanopoda, Euphausia, Thysanoëssa* and *Stylocheiron* (Boden et al. 1955; Ponomoreva 1963). Euphausiids are generally thought to make diurnal vertical migrations, remaining at depth (usually below 500 m) during the day and ascending at night to 100 m or less. However, this is complicated by the fact that as euphasiids grow they are found at deeper depths, except during spawning, which occurs in surface waters. Spawning occurs in spring to take advantage of the spring phytoplankton bloom, and the hatched nauplii larvae live near the surface (down to about 25 m). By fall and winter, the young crustaceans are found mainly at depths of 100 m or less, and make diurnal vertical migrations. Sexual maturity is reached the following spring at age 1. After spawning, adult euphausiids gradually descend to deeper depths until fall and winter, when they no longer migrate daily to near-surface waters. In their second spring, they again rise to the surface to spawn; euphausiids older than 2 years are very rarely found. This classical view of euphausiid life history and longevity was recently questioned by Nicol (1990), who reported that Antarctic euphausiids may live as long as 6-10 years; annual euphausiid production, then, would be much lower than if they lived only 2 years.

While euphausiids are found throughout oceanic and neritic waters, their swarms are most commonly encountered in areas where nutrients are available for phytoplankton growth. This occurs primarily in

areas where upwelling of waters from depth into the surface region is a consistent oceanographic feature. Areas with such features are at the edges of the various domains on the shelf or at the shelf-break, at the heads of submarine canyons, on the edges of gullies on the continental shelf (e.g., Shumagin, Barnabus, Shelikof gullies in the Gulf of Alaska), in island passes (on certain tides) in the Aleutian Islands (e.g., Seguam Pass, Tanaga Pass), and around submerged seamounts (e.g. , west of Kiska Island). It is no coincidence that these are also prime fishing locations used by commercial fishing vessels seeking zooplanktivorous groundfish, such as walleye pollock, Atka mackerel, sablefish and many species of rockfish and flatfish (Livingston and Goiney 1983; Fritz 1993; Yang 1993).

The species comprising the euphausiid group occupy a position of considerable importance within the North Pacific food web. Euphausiids are fed upon by almost all other major taxa inhabiting the pelagic realm. The diet of many species of fish other than the groundfish listed above, including salmon, smelts (capelin, eulachon, and other osmerids), gadids (Arctic cod and Pacific tomcod), and Pacific herring is composed, to varying degrees, by euphausiids (Livingston and Goiney 1983), while euphausiids are the principal item in the diet of most baleen whales (e.g. minke, fin, sei, humpback, right, and bowhead whales; Perez 1990). While copepods generally constitute the major portion of the diet of planktivorous birds (e.g. auklets), euphausiids are prominent in the diets of some predominately piscivorous birds in some areas (e.g. kittiwakes on Buldir Island in the Aleutians, Middleton Island in the Gulf of Alaska, and St. Matthew Island in the Bering Sea; Hatch et al. 1990). Euphausiids are not currently sought for human use or consumption from the North Pacific ocean on a scale other than local, but large (about 500,000 mt per year) krill fisheries from Japan and Russia have been operating in Antarctic waters since the early 1980s (Swartzman and Hofman 1991).

Pholidae (Gunnels) and Stichaeidae (Pricklebacks, Warbonnets, Eelblennys, Cockscombs and Shannys). Gunnels and pricklebacks are long, compressed, eel-like fishes with long dorsal fins often joined with the caudal fin. Pricklebacks are so named because all rays in the dorsal fin are spinous in most species (while some may have soft rays at the rear of the dorsal fins). Gunnels have flexible dorsal fin rays, and differ from pricklebacks in that the anal fin is smaller (the distance from the tip of the snout to the front of the anal fin is shorter than the length of the anal fin). Most species of both families live in shallow nearshore waters among seaweed and under rocks and are mostly less than 45 cm in length. There are approximately 14 species of Stichaeidae and 5 species of Pholidae in Alaska. Nothing is known about absolute or trends in their abundance, and little about their growth rates, maturity schedules, and trophic relationships. They feed mostly on small crustacea and arthropods, and are thought to grow quickly. Some cockscombs in British Columbia attain sexual maturity at age 2 years.

Gonostomatidae (Bristlemouths, Lightfishes, Anglemouths). This is a large and diverse family of small (to about 8 cm), bathypelagic fish that are rarely observed except by researchers. They can be abundant at depths of up to 5000 m. There may be as many as 6 species in the North Pacific Ocean and Bering Sea.

7.2.2 Diets of Forage Fish Species in the North Pacific

Bathylagid. Since bathylagids have a small mouth, dense flat gill rakers, a small stomach and long intestine, they consume weak swimming soft-bodied animals (pteropods, appendicularia, ctenophores, chaetognath, polychaete, jellyfish etc.). Bathylagids in the epipelagic zone can also feed on euphausiids and copepods at night when they are abundant (Gorelova and Kobylyanskiy, 1985; Balanov, et al., 1995).

Myctophid. Because of their large mouth, relatively sparse and denticulate gill rakers, well developed stomach and short intestine, myctophids mostly consume actively swimming animals like copepods and euphausiids (Balanov, et al. 1995).

Pacific sandfish. The diet of sandfish consists of small crustaceans such as mysids, amphipods, and cumaceans (Mineva 1955, Kenyon 1956).

Eulachon. The diet of eulachon in the North Pacific generally consists of planktonic prey (Hart, 1973; Macy et al., 1978). As larvae they primarily consume copepod larvae; post-larvae consume a wider variety of prey that includes phytoplankton, copepod eggs, copepods, mysids, ostracods, barnacle larvae, cladocerans worm larvae and larval eulachon. Juvenile and adult eulachon feed almost exclusively on euphausiids, with copepods and cumaceans occasionally in the diet.

Sand lance. Hart (1973) and Trumble (1973) summarized the diet of sand lance in the North Pacific as primarily planktivorous; their primary prey changing with ontogeny. Larval sand lance consume diatoms and dinoflagellates; post-larvae prey upon copepods and copepod nauplii. Adult sand lance prey upon chaetagnaths, fish larvae, amphipods, annelids and common copepods. Sand lance exhibit seasonal and diurnal variation in feeding activity and are opportunistic feeders upon abundant plankton blooms.

Capelin. The diet of capelin in the north Pacific as summarized by Hart (1973) and Trumble (1973) is primarily planktivorous. Small crustaceans such as euphausiids and copepods are common to the diet of capelin, although marine worms and small fish are also part of their diet. In the Bering Sea, adult capelin consume copepods, mysids, euphausiids, and chaetognaths. Juveniles primarily consume only copepods (Naumenko, 1984). The largest capelin (>13cm) consume euphausiids nearly exclusively. Capelin feed throughout the year in the Bering Sea. However, the diet exhibits seasonal variation that is due in part to spawning migration and behavior.

The primarily planktivorous diets of eulachon, sand lance, and capelin reduce the potential for dietary competition with the piscivorous and benthic diets of most groundfish. However, the potential for dietary competition is greater between pollock and forage fish due to the importance of planktonic prey such as euphausiids and copepods in their diets.

Gonostomatid. Gonostomatids have large gill openings and well-developed gill rakers, characteristics of a zooplankton feeder. The primary zooplankton prey of gonostomatids are calanoid copepods. The other food includes ostracods and euphausiids. Some larger gonostomatids also consume some fish (Gorelova 1980).

Stichaeidae. There are many species in the Family Stichaeidae, a family with long, slender, compressed bodies. Some of the diets of the stichaeids are described below. The longsnout prickleback eats copepods almost exclusively (Barraclough 1967). Young ribbon pricklebacks eat copepods and oikopleura (Robinson, Barraclough and Fulton 1968). The food of the adults of this species includes crustaceans and red and green algae. Black prickleback consumed copepods, copepod nauplii and clam larvae (Barraclough, Robinson, and Fulton 1968). Peppar (1965) reported that the important food of high cockscomb was green algae. Other food of this species included polychaete worms, amphipods, molluscs, and crustaceans.

Euphausiacea. The diets of euphausiids in the North Pacific consist of planktonic prey. Species of the genus Euphausia consume diatoms, dinoflagellates, tintinnids, chaetagnaths, echinoderm larvae, amphipods, crustacean larvae, ommatidians, and detritus (Mauchline 1980). Species of the genus

Thysannoessa consume diatoms, dinoflagellates, tintinnids, radiolarians, foraminiferans, chaetagnaths, echinoderm larvae, molluscs, crustacean larvae, ommatidians and detritus (Mauchline 1980). Several species of Thysannoessa also consume walleye pollock eggs in the Gulf of Alaska (Brodeur and Merati 1993).

Pholidae. The diets of gunnels (family Pholidae) consists primarily of benthic and epibenthic prey. Amphipods, isopods, polychaete worms, harpacticoid copepods, cumaceans, munid crabs, insects, mysids, algae, ostracods, bivalves, crustacean larvae, and tunicates have been described as their main prey (Clemens and Wilby 1961, Simenstad et al. 1979, Williams 1994). Juvenile fish prey (English sole, *Parophry vetulus*, and sand lance, *Ammodytes hexapterus*) have also been described as infrequent components of the diet in Puget Sound, Washington (Simenstad et al. 1977).

7.2.3 Significance of Forage Fish in the Diet of Groundfish

Bering Sea

Forage fish, as defined in this EA, are found in the diets of walleye pollock, Pacific cod, arrowtooth flounder, Pacific halibut, Greenland halibut, yellowfin sole, rock sole, Alaska plaice, flathead sole, and skates in the eastern Bering Sea region. However, forage fish do not represent a large portion of the diet by weight of these predators with the exception of shelf rock sole (14.3%) and slope pollock (12.6%).

Eastern Bering Sea Shelf. Despite the generally piscivorous diet of cod, arrowtooth flounder, Pacific halibut, Greenland turbot and skates, forage fish are not principal components in the diet by weight. Sand lance are the most prevalent forage fish in the diet of cod (0.8%) while capelin, Osmeridae, Bathylagidae, Myctophidae, and eulachon each represent 0.1% or less of the diet by weight. In the diet of arrowtooth flounder, capelin and eulachon each represent 0.2% of the diet by weight, while Osmeridae, Myctophidae, and sand lance each constitute 0.1% or less. The diet of Pacific halibut contains 2.2% sand lance and 1.8% capelin; Osmeridae and eulachon each represent 0.1% or less. Myctophidae represent 0.2% of the diet of Greenland turbot; Bathylagidae, Osmeridae, and sand lance represent 0.1% or less. Sand lance are the most important forage fish in the diet of skates (0.7%); capelin, sandfish, and Myctophidae each represent 0.1% or less.

Sand lance is the most prevalent forage fish species in the diet of walleye pollock (0.5%); Osmeridae, Bathylagidae, Myctophidae, and eulachon each represent <0.1% of the diet by weight. The total contribution (0.6%) of forage fishes to the diet of yellowfin sole is primarily due to sand lance; Bathylagidae and capelin each represent <0.1% by weight. Sand lance are the second most important prey in the diet of rock sole, 14.3% by weight; Osmeridae are the only other forage fish present in the diet (<0.1%). Sand lance are the only forage fish found in the diet of Alaska plaice, representing 0.5% of the diet. Flathead sole consumes capelin (1.3%), sand lance (0.5%), Osmeridae (0.1%) and Myctophidae (<0.1%).

Eastern Bering Sea Slope. Lang and Livingston (1996) studied the diets of groundfish in the eastern Bering Sea slope region. In this region, forage fish are relatively unimportant in the diets of Greenland halibut, flathead sole, arrowtooth flounder, and cod. However, 12.6 % of the diet of pollock on the slope consists of forage fishes. Greenland halibut consume Bathylagidae (0.4%) and Myctophidae (0.4%) as the only forage fish in their diet. Flathead sole also consumed Bathylagidae (0.3%) and Myctophidae (0.1%). Myctophidae (0.2%) is the only forage fish found in the diet of arrowtooth flounder. Pollock consume Bathylagidae (7.0%), Myctophidae (5.5%), Osmeridae (0.1%), and sand lance (<0.1%). Forage fish are negligible in the diet of cod; Bathylagidae represent <0.1% of the diet by weight.

Gulf of Alaska

Yang (1993) studied the diets of groundfish in the Gulf of Alaska shelf during summer. He found that the main fish prey of groundfish in the Gulf of Alaska included walleye pollock, Pacific herring, capelin, Pacific sand lance, eulachon, Atka mackerel, bathylagids, and myctophids. Although walleye pollock was the most important fish prey of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and walleye pollock in the Gulf of Alaska area, other forage fish species comprised 1-18% of the diet of groundfish. Capelin was important food of arrowtooth flounder and pollock, comprising 8% and 13 % of the diet of arrowtooth flounder and walleye pollock, respectively. The capelin consumed by these groundfish were mainly located in the northeast and southwest of Kodiak Island. Eulachon comprised 6% of the food of sablefish. Myctophids were important forage fish for shortraker rockfish, comprising 18% of the diet of shortraker rockfish. Pacific sand lance were found in the stomachs of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and walleye pollock, but its contribution to the diet was small ($\leq$1 %). Bathylagids were only found in the diet of walleye pollock, they contributed less than 1% of the diet of walleye pollock. Pacific sandfish was not found in the diet of the groundfish in the Gulf of Alaska area.

In the Atlantic, strong interactions between cod and capelin have been recorded (Akenhead, et al. 1982). Even though Pacific cod did not feed so heavily on capelin in the Gulf of Alaska, capelin was one of the important fish prey of several groundfish species. The distributions and the abundances of the forage fish in the Gulf of Alaska are not well known. However, a series of years with poor forage fish recruitment, which decreases the availability of small fish, may have greater impact on piscivorous groundfishes.

Aleutian Islands

Yang (1996) studied the diets of groundfish in the Aleutian Islands during summer. He found that main fish prey of groundfish in the Aleutian Islands included Atka mackerel, walleye pollock, Pacific herring, capelin, myctophids, bathylagids, Pacific sand lance, and eulachon. Although Atka mackerel and walleye pollock were important fish prey of arrowtooth flounder, Pacific halibut, and Pacific cod, other forage fish species comprised from 1-37% of the diet of groundfish. Most of the Atka mackerel consumed by the groundfish were located near Attu, Agattu, Amchitka, Tanaga, Atka, and Unalaska Islands. Myctophids were an important forage fish. Large amounts of myctophids were found in the diets of Greenland turbot, walleye pollock, Pacific ocean perch, and short raker rockfish. They were also found in arrowtooth flounder, Pacific cod, rougheye rockfish, Atka mackerel, and northern rockfish. Most myctophids consumed by the groundfish were located near Kiska, Adak, Seguam, and Yunaska Islands. It is notable that nine out of eleven groundfish species shown in Table 4 consumed myctophids as food. If the abundance of the myctophids declines dramatically, it could impact the growth of groundfish in the Aleutian Islands area which depend on myctophids for a main food resource. Bathylagids were found in the diets of Greenland turbot and walleye pollock. Capelin were found in the diet of Pacific halibut and walleye pollock collected in the Akutan Island area, but they contributed only 5% and less than 1% of the diets of Pacific halibut and walleye pollock, respectively. Pacific sand lance were food of arrowtooth flounder, Pacific halibut, Pacific cod, and walleye pollock, but they contributed less than 1% of the diets. Only a small amount (less than 1%) of eulachon was found in the diet of walleye pollock. Pacific sandfish was not found in the diets of the groundfish in the Aleutian Islands area.

Other Forage Species in the Diets of Bering Sea, Gulf of Alaska, and Aleutian Islands Groundfish

Euphausiacea. Euphausiids represent a significant portion of the diet of walleye pollock in the eastern Bering Sea Shelf region (Livingston 1991a). Euphausiids represent as much as 70% of the diet in the winter and spring and are generally more important to larger pollock than smaller ones. Euphausiids are

also the primary prey of small (<35 cm) Greenland turbot in the eastern Bering Sea shelf, but are of little importance to larger fish (Livingston and deReynier 1996). Small (< 35 cm) arrowtooth flounder also consume euphausiids as a large (50% by weight) portion of their diet; euphausiids are of little importance to the larger ones (Livingston and deReynier 1996). Euphausiids were not found as a significant component of the diet of any other eastern Bering Sea shelf groundfish.

In the eastern Bering Sea slope region euphausiids were found in the diets of several groundfish species. Euphausiids represent 26% of the overall diet by weight of walleye pollock but are more important seasonally (80% by weight in winter) and are more important to smaller (<50 cm) fish (Lang and Livingston 1996). Euphausiids also play a small role (<1% by weight) in the diets of Pacific cod, flathead sole, and arrowtooth flounder (Lang and Livingston 1996).

Euphausiids are an important food item of many groundfish species in the Gulf of Alaska and Aleutian Islands areas. Yang (1993) showed that the diets of plankton feeding groundfish in the Gulf of Alaska such as dusky rockfish, Pacific ocean perch, and northern rockfish had large percentages (more than 65%) of euphausiids. Euphausiids also comprised 39% of the diet of walleye pollock in the Gulf of Alaska. In the Aleutian Islands, euphausiids also comprised 43, 55, 51, and 50% of the stomach contents of walleye pollock, Atka mackerel, Pacific ocean perch, and northern rockfish, respectively. Euphausiids were also a constituent of the diets of arrowtooth flounder (5%), rougheye rockfish (2%), shortspine thornyhead (1%), and shortraker rockfish (1%) in the Aleutian Islands. (Yang 1996).

Stichaeids. Stichaeids represent a minimal portion of the diets of several groundfish species in the eastern Bering Sea shelf region. Pacific cod (Livingston 1991b), arrowtooth flounder (Yang 1991a), and flathead sole (Pacunski 1991) consume unidentified stichaeids as < 1% of their diets by weight. Greenland turbot consume a combination of unidentified stichaeids and daubed shanny (*Lumpenus maculatus*) as a small portion (<1%) of their diet.

Stichaeids represent a small portion (<1% by weight) of the diet of Pacific cod, arrowtooth flounder, and Greenland turbot in the eastern Bering Sea slope region (Lang and Livingston 1996). Yang (1993) studied the diets of the groundfish in the Gulf of Alaska area during summer. He found that stichaeids comprised about 1% of the stomach content weight of arrowtooth flounder, Pacific cod, and walleye pollock, respectively. Pacific halibut, sablefish, and Pacific ocean perch also consumed stichaeids, but their contribution to the diets was small (<1%). Yang (1996) also studied the diet of the groundfish in the Aleutian Islands area. He found that stichaeids comprised 2% of the stomach contents weight of arrowtooth flounder. Stichaeids comprised <1% of the diets of Pacific cod, walleye pollock, and Atka mackerel.

Gonostomatids. Gonostomatids were not found as a significant portion of the diets of eastern Bering Sea shelf or slope groundfish (Livingston and deReynier, 1996). Gonostomatids are probably not important prey of the groundfish in the Gulf of Alaska area since they were not found in a recent study of groundfish diets in that area (Yang 1993). Gonostomastids were found in walleye pollock stomachs in the Aleutian Islands area; however, they contributed less than 1% of the total stomach contents weight (Yang 1996).

Pholids. Pholids (saddleback gunnel) were found in the Pacific cod stomachs in the Aleutian Islands area; their contribution was less than 1% of the total stomach contents weight. Pholids were not found as a significant portion of the diets of eastern Bering Sea shelf or slope groundfish. Pholids are probably not important prey of the groundfish in the Gulf of Alaska area since they were not found in a recent study of groundfish diets in that area (Yang 1993).

See table of contents for the following map:

Figure 8.1 Distribution of capelin, rainbow smelt, and eulochon in the Bering Sea, as indicated by the Alaska Fisheries Science Center summer groundfish trawl surveys.

7.2.4 References

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